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GENERATION AND STABILITY OF CANADIAN

MINE/SMELTER EFFLUENT TREATMENT SLUDGES

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SUMMARY

GIONET MELLOR LIEBICH ASSOCIATES LIMITED has conducted a study of the generation and stability of water effluent treatment sludges in the Canadian Mineral Industry. The study consisted of a survey of operating treatment facilities, laboratory sludge characterization studies (chemical and physical parameters), and sludge leaching studies to evaluate stability characteristics. The main findings were as follows:

1.0 SURVEY RESULTS

1.1 A total of 42 Canadian effluent treatment facilities were identified, 28 of which were operated by base metal, 8 by precious metal, and 6 by uranium producers.

1.2 In nearly all cases, lime neutralization is used by base metal and uranium producers, resulting in substantial sludge generation. Precious metal producers are mainly concerned with cyanide destruction, and utilize CN oxidation processes, which produce lower sludge quantities.

1.3 The quantity of sludge generated by the facilities surveyed is estimated at 140,000 dry tonnes/year and is mainly produced by the base metal industry.

1.4 A review of solid-liquid practices indicated 49% of the facilities used mechanical (clarifiers and filters) systems. The others used settling and tailings ponds.

1.5 In the majority of cases, the sludges are disposed off at the mine/plant site in tailings or sludge ponds.

2.0 SLUDGE CHARACTERIZATION

2.1 Analysis of sixteen sludge samples has indicated calcium, iron, and zinc to be the main components in most of the sludges, with concentrations averaging 11%, 6% and 6% respectively.

2.2 Sludge densities varied from 1% to 30%. Those below 5% were produced in settling ponds and conventionally operated clarifiers. Concentration above 15% were found in clarifiers operated in the High Sludge Density mode, involving sludge recycle to the neutralization reactors.

3.0 SLUDGE STABILITY

3.1 Leaching tests of sixteen sludge samples have shown the release of contaminants to be highly related to the final pH of the leachate solutions and to initial metal concentration of sludges.

3.2 Highest releases were for zinc, iron, and copper with concentrations in leach solutions as high as 5200 mg/L Zn, 770 mg/L Fe, and 93 mg/L Cu.

3.3 There did not appear to be appreciable difference in leach contaminant level between fresh and aged sludges.

3.4 A comparison of leach solution concentrations to Quebec regulatory levels for Hazardous Wastes indicates Zn, Ni, Cd, Cu, and Pb to exceed the requirements in up to 50% of the sludge samples tested.

3.5 In many cases, effluent treatment sludges are disposed with tailings. The long-term effects of such action is uncertain, and need to be evaluated.

1.0 INTRODUCTION

The extraction and processing of ores by the Canadian Mineral Industry results in the generation of contaminated water which generally requires treatment prior to discharge. The main contaminants-acidity, cyanides, and dissolved metals result mainly from atmospheric exposure of sulphides in ores and waste rock, and reagent addition during processing of ores. In order to remove these contaminants, the industry has installed in the past decade numerous facilities to treat wastewaters with reagents (usually lime), producing purified water and sludges containing the contaminants. While these sludges are generally disposed of at the mine/smelter sites, little information exists regarding such aspects as:

.Volumes of sludges generated in Canada by mine/smelter operations
.Composition and nature of sludges
.Current methods of disposal and effectiveness
.Stabilities of the disposed sludges

In order to elucidate these aspects, Gionet Mellor Liebich Associates Limited (GML) has undertaken a project sponsored by the Mineral Sciences Laboratories of CANMET, and Supply and Services Canada. The results of the work carried out are presented in this report. A coding system was used to maintain confidentiality as to some of the test results, with individual locations identified as either base metal (BM) or precious metal (PM).

2.0 SURVEY OF EFFLUENT TREATMENT PLANTS

The preliminary phase of the study involved the identification and operational review of wastewater treatment facilities operated by the Canadian Mineral Industry.

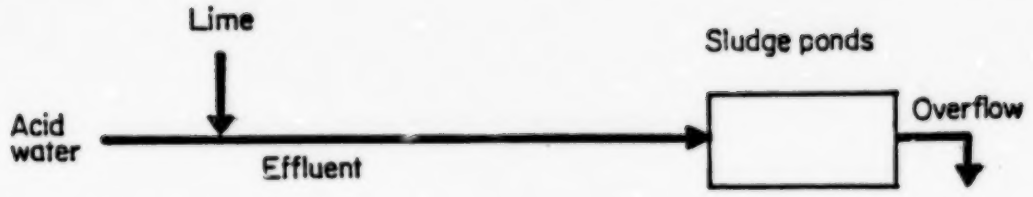
2.1 SURVEY METHODOLOGY

The survey consisted principally of identifying and contacting operating Canadian mines, to document their effluent systems and treatment practices. The 1985 Canadian Minerals Yearbook [1] was used to identify the producers, with subsequent contact of most of these mines by telephone in the period December 1985 to March 1986. Questions were directed to either the appropriate environmental coordinators, or to superintendents. In addition, both provincial and federal regulatory personnel (ie., Environment Canada, and provincial Departments of Environment or Mines) were contacted. The telephone questionnaire format, listing of mines used in the study, and the list of personnel contacted for the study are all presented in Appendices 1 and 2.

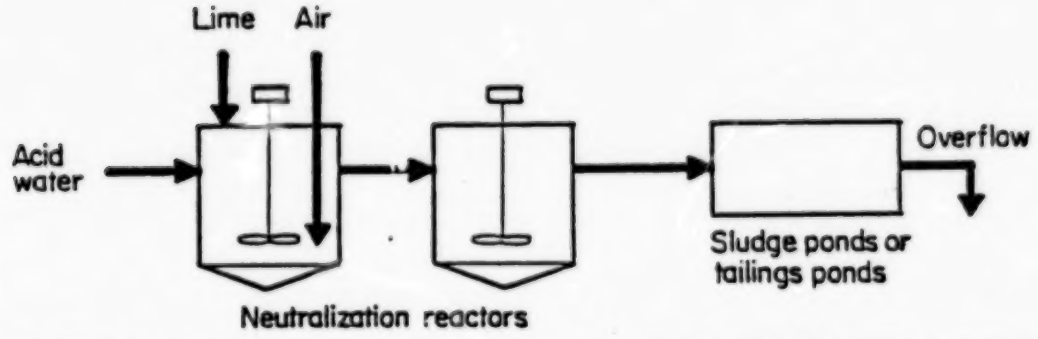
For the purpose of the study, effluent treatment facilities considered were those where chemical reagents such as lime, caustic, chloride, sulphur dioxide, hydrogen peroxide, iron chloride, etc., are added to promote acid neutralization, metal precipitation and/or coprecipitation, and cyanide destruction. Natural degradation ponds used by some mines (mainly for cyanide and thiosalt oxidation) were excluded. Also excluded were facilities where lime is added directly to the tailings lines, and the precipitates settle with tailings.

The facilities considered can be classified as follows:

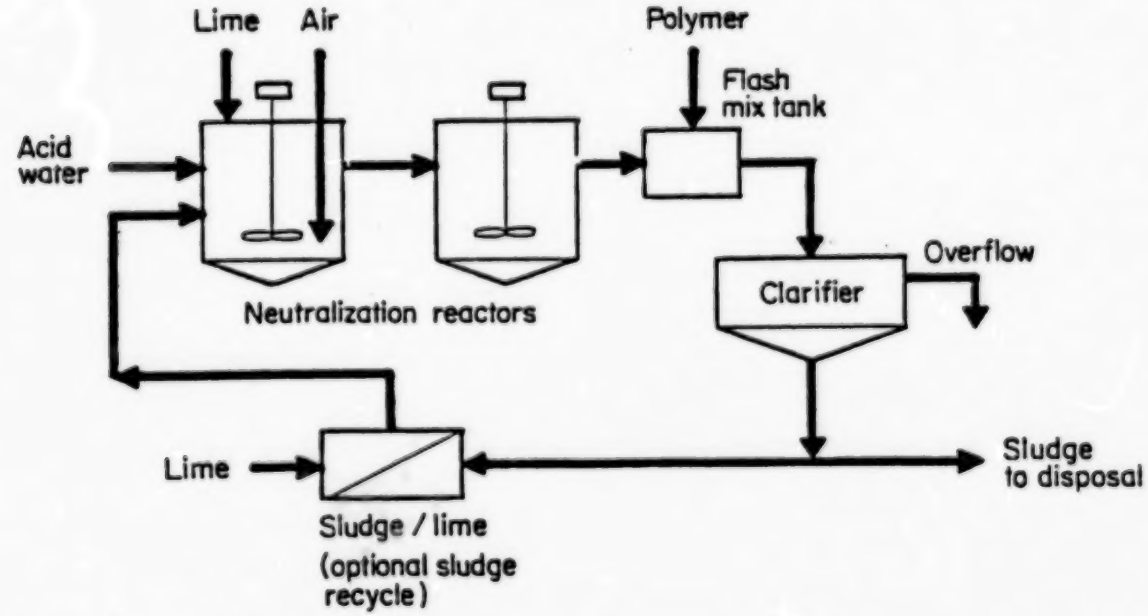
Lime Neutralization: Lime is added to wastewaters to neutralize acidity and precipitate heavy metals. Three principal types of facilities considered are illustrated in Figure 1, and can be grouped as follows:



Type 1. Lime addition to effluent or tailings lines.



Type 2. Lime addition to neutralization reactors. Solid/liquid separation in ponds.



Type 3. Lime addition to neutralization reactors. Solid/liquid separation in clarifiers.

FIGURE 1: Types of lime addition facilities

Type 1 - Lime is added as a slurry (usually 5 to 20%) directly to effluent discharge pipe. Precipitates settle out in sludge ponds.

Type 2 - Mechanically or air agitated reactors provide more efficient acid water/reagent contact. Air may also be added to promote oxidation of ferrous iron to the ferric form. The reactor discharge is sent to sludge or tailings ponds for solid/liquid separation.

Type 3 - A more efficient solid/liquid separation is achieved using mechanical clarifiers (either conventional or plate pack) following the reactors. Sludge from clarifiers is generally disposed of in tailings or sludge ponds. In some cases, sludge is recycled to the reactors to achieve higher solids densities.

The Canadian Mineral Industry operates waste water treatment facilities to remove such contaminants as cyanide, arsenic, and antimony. Often, such treatment is in addition to or jointly with lime neutralization, and facilities used are similar to those indicated in Figure 1.

2.2 SURVEY RESULTS

The list and description of wastewater treatment facilities operated by the Canadian Mineral industry, as identified by the survey, is presented in Tables 1 to 3, under base metal, precious metal, and uranium group classifications. The information indicates the following:

TABLE 1

SUMMARY OF BASE METAL INDUSTRY WASTEWATER TREATMENT

MINE	EFFLUENT FLOW m^3/hr	TREATMENT PLANT DESCRIPTION
BRUNSWICK MINING AND SMELTING CORP. LTD., MINING DIVISION, BATHURST, N.B. No. 12 site	$90m^3/hr$	1a) Lime treatment of mine water. (Lime addition in mechanically agitated reactor then disposal to tailings ponds).
	$275m^3/hr$	1b) Lime treatment of mill thickener overflow. (Lime addition and aeration in mechanically agitated reactors, then disposal to tailings ponds).
	$800m^3/hr$	2) Lime treatment of tailings decant. (Lime addition in reactor. Settling and sludge disposal in sludge ponds).
No. 6 site	$280m^3/hr$	3) Lime treatment of acid mine drainage. (Lime addition in mechanically agitated reactor then disposal to open pit mine).
BRUNSWICK MINING AND SMELTING CORP. LTD., SMELTING DIVISION, BELLEDUNE, N.B.	$125m^3/hr$	4) Lime treatment of combined stream of recycled process water, surface drainage, sewage. (Lime addition in mechanically agitated reactors, polymer addition, mechanical circular clarifier settling).
NORANDA, INC. HORNE DIVISION (WAITE AMULET) NORANDA, QUE.	$220m^3/hr$	5) Lime treatment of abandoned tailings seepage. (Lime addition and aeration in mechanically agitated reactors, polymer addition, lamella clarifier settling, sludge recycle to promote high sludge density).
NORANDA, INC. LES MINES GALLEN NORANDA, QUE.	$110m^3/hr$	6) Lime treatment of acid mine water. (Lime addition and aeration in mechanically agitated reactors, polymer addition, lamella clarifier settling, sludge recycle to promote high sludge density).

TABLE 1 (cont'd)

SUMMARY OF BASE METAL INDUSTRY WASTEWATER TREATMENT

MINE	EFFLUENT FLOW m^3/hr		TREATMENT PLANT DESCRIPTION
CORP. FALCONBRIDGE COPPER, LAKE DUFAULT DIVISION NORANDA, QUE.	N/A	7)	Lime treatment of oxidation pond decant. (Lime addition, settling in precipitation pond).
CANADIAN ELECTROLYTIC ZINC VALLEYFIELD, QUE.	$265m^3/hr$	8)	Lime treatment of spent electrolyte, acidic plant effluents and ditch water. (lime addition in mechanically agitated reactors. Solid-liquid separation in settling lagoons and decant discharged)
FALCONBRIDGE LTD. FALCONBRIDGE, ONT.	$670m^3/hr$	9)	Lime treatment of tailings decant. (Lime addition and aeration in air agitated outdoor concrete mixing basin, settling in a 155 acre settling pond).
FALCONBRIDGE LTD. SUDBURY, ONT.	$1800m^3/hr$	10)	Limestone treatment of acidic tailings decant. (Limestone slurry added to acidic water overflow weir, solids settling in lake).
	N/A	11)	Caustic treatment of mine water, yard drainage. (NaOH addition to pump discharge, settling in pond, precipitates dredged and processed in mill).
NORANDA, INC. GECO DIVISION MANITOUWADGE, ONT.	$180m^3/hr$	12)	Lime treatment of combined tailings seepage and water. (Lime addition and aeration in air agitated reactor, polymer addition, reactor-clarifier settling, sludge disposal from clarifier to tailings ponds).

TABLE 1 (cont'd)

SUMMARY OF BASE METAL INDUSTRY WASTEWATER TREATMENT

MINE	EFFLUENT FLOW m^3/hr	TREATMENT PLANT DESCRIPTION
INCO, LTD. COPPER CLIFF, ONT.	$4200m^3/hr$	13) Lime treatment of combined mine, mill, smelter, refinery decants. (Lime and polymer addition, settling in reactor-clarifier, sludge disposal from clarifier to tailings pond).
INCO, LTD. NOLIN CREEK, ONT.	$420m^3/hr$	14) Lime treatment of tailings decant. (Lime and polymer addition settling in reactor-clarifier, sludge disposal in recycle water pond, occasionally dredged, and recycled to ore processing).
INCO, LTD. GARSON, ONT.	$125m^3/hr$	15) Lime treatment of drainage. (Lime and polymer addition settling in reactor-clarifier, sludge dewatered in sludge bed, trucked to approved landfill).
INCO, LTD. PORT COLBORNE, ONT.	$850m^3/hr$	16) Lime treatment of refinery effluents. (Lime and polymer addition, settling in reactor-clarifier, sludge dewatered in drum filter, sent to approved landfill).
KIDD CREEK MINES LTD. TIMMINS, ONT.	$1800m^3/hr$	17) Lime treatment of tailings decant. (Lime addition at discharge, sludge settling in sludge pond).
MATTABI MINES LTD. IGNACE, ONT.	$270m^3/hr$	18) Lime treatment of tailings decant. (Lime addition in mechanically agitated reactors, polymer addition solids settling and disposal in pond).

TABLE 1 (cont'd)

SUMMARY OF BASE METAL INDUSTRY WASTEWATER TREATMENT

MINE	EFFLUENT FLOW m^3/hr		TREATMENT PLANT DESCRIPTION
SHERRITT GORDON MINES LTD. LYNN LAKE, MAN. (RUTTAN MINE)	$220m^3/hr$	19)	Lime treatment of tailings decant. (Lime addition to stream, sludge settling in sludge pond).
HUDSON BAY MINING & SMELTING CO. LTD. FLIN FLON, MAN.	$50m^3/hr$	20)	Lime treatment of zinc refinery process waters. (Lime and polymer addition in reactor box, settling in mechanical circular clarifier, sludge recycled to reactor box, and to oxide leaching plant for zinc recovery).
HUDSON BAY MINING & SMELTING CO. LTD. SPRUCE POINT MINE SNOW LAKE, MAN.	$10m^3/hr$	21)	Lime treatment of minewater drainage, underground seepage, and process water. (Lime and polymer addition in reactor clarifier, sludge settled in clarifier, then pumped out to sludge storage pond).
HUDSON BAY MINING & SMELTING CO. LTD. CHIESEL-GHOST MINE SNOW LAKE, MAN.	$40m^3/hr$	22)	Lime treatment of minewater drainage, underground seepage, and process water. (Lime and polymer addition in reactor clarifier, sludge settled in clarifier, then pumped out to sludge storage pond).
COMINCO LTD. SULLIVAN CONCENTRATOR KIMBERLEY, B.C.	$1000m^3/hr$	23)	Lime treatment of mine/mill effluents (Lime and recirculated sludge are blended, then combined with acid water in agitated and aerated reactor. Polymer added and solids settled in clarifier, partly recycled to promote high sludge density, partly disposed to sludge drying bed).

TABLE 1 (cont'd)

SUMMARY OF BASE METAL INDUSTRY WASTEWATER TREATMENT

MINE	EFFLUENT FLOW m^3/hr		TREATMENT PLANT DESCRIPTION
COMINCO LTD. TRAIL, B.C. SMELTER	$300m^3/hr$	24)	Lime treatment of smelter effluents. (Lime and recirculated sludge are blended, then combined with feed water in agitated reactor. Polymer added and solids settled in clarifier, partly recycled to promote high sludge density, partly recycled to smelter for metal value recovery).
WESTMIN RESOURCES LTD. CAMPBELL RIVER, B.C.	N/A	25)	Lime treatment of contaminated ground water. (Lime addition to flowing channel, solids settling in sludge pond, then pumped out to tailings pond).
	N/A	26)	Lime treatment of mine water. (Lime addition, solids settling in sludge pond, then pumped out to tailings pond).
	$40m^3/hr$	27)	Alkaline chlorination treatment of thickener overflows. (Chlorine and lime addition in three agitated reactors in series, discharge to lake).
PINE POINT MINES LTD. N.W.T.	N/A	28)	Lime treatment of tailings decant. (Lime addition to decant, solids settling in sludge pond, sludge pumped out once per year to tailings pond).

TABLE 2

SUMMARY OF PRECIOUS METAL INDUSTRY WASTEWATER TREATMENT

MINE	EFFLUENT FLOW m^3/hr	TREATMENT PLANT DESCRIPTION
KIENA GOLD MINES LTD. VAL D'OR, QUE.	$110m^3/hr$	1) SO_2-Air process for cyanide destruction, (treated in agitated reactor with SO_2, air, and Cu added, disposal in tailings area).
MINE MUSCOCHO MONTAUBAN, QUE.	$20m^3/hr$	2) SO_2-Air process for cyanide destruction, (treated in agitated reactor with addition of sodium metabisulfite, solids settling in a 11 day retention settling, and a 30 day retention polishing pond).
DETOUR JOINT VENTURE JAMES BAY, ONT.		3) N/A
NORANDA, INC. HEMLO DIVISION MARATHON, ONT.	$200m^3/hr$	4) Cyanide/antimony chemical treatment process (confidential). (Tailings decant treated in two stage process consisting of CN destruction in mechanically agitated reactors, settling in reactor-type mechanical clarifier Sb precipitation in mechanically agitated reactors, and settling in reactor-type mechanical clarifier. Sludge disposal from clarifier to tailings pond.
TECK-CORONA MARATHON, ONT.	$105m^3/hr$	5) Cyanide chemical treatment of tailings pond decant water (H_2O_2 and Cu catalyst for CN removal). Subsequent treatment for precipitation in a reactor-type clarifier. Polymer and flocculant are added and treated effluent discharged to lake. Sludges disposed to tailings pond.

TABLE 2 (cont'd)

SUMMARY OF PRECIOUS METAL INDUSTRY WASTEWATER TREATMENT

MINE	EFFLUENT FLOW m^3/hr	TREATMENT PLANT DESCRIPTION
EQUITY SILVER MINES LTD. HOUSTON, B.C.	$100m^3/hr$	6) Lime treatment of acid mine drainage, (lime addition in mechanically agitated reactor. Solids settling in settling ponds. Sludge pumped from settling pond to tailings line).
COMINCO LTD. CON MINE YELLOWKNIFE, N.W.T.	$230m^3/hr$	7) Cyanide/arsenic chemical treatment of tailings water, (tailings water treated in mechanically agitated reactor with $CuSO_4$ and H_2O_2 for CN removal. Subsequent treatment in second mechanically agitated reactor with ferric sulphate for As precipitation. Lime added for pH control. Polymer added, settling in a lamella-type clarifier, sludge partly recycled to second reactor, partly disposed to tailings pond).
GIANT YELLOWKNIFE MINES LTD. YELLOWKNIFE, N.W.T.	$280m^3/hr$	8) Cyanide/arsenic chemical treatment of tailings decant (lime added in tailings line decant water then treated in mechanically agitated reactor with chloride for CN removal. $FeSO_4$ and sulphuric acid added in second reactor for Arsenic precipitation. Polymer floculants are added in third agitated tank, and treated effluent discharged to different tailings pond).

TABLE 3

SUMMARY OF URANIUM INDUSTRY WASTEWATER TREATMENT

MINE	EFFLUENT FLOW m^3/hr	TREATMENT PLANT DESCRIPTION
RIO ALGOM ELLIOT LAKE, ONT.		
.QUIRKE MINE	$550m^3/hr$	1) Lime/barium treatment of acidic tailings water. (Lime and barium chloride added for neutralization and radium precipitation. Solids settle in settling ponds, which are cleaned out once per year using Mud-cat type barge dredge).
.PANEL MINE	$410m^3/hr$	2) Lime treatment of acidic tailing water. (Lime added for neutralization, solids settled in 2 Hypelon lined settling ponds. Solids generation low).
.STANLEIGH MINE	$1300m^3/hr$	3) Lime/barium treatment of acidic tailing water. (Lime and barium chloride added to 5 mechanically agitated reactors in series. Solid/liquid separation in 7 sand/anthracite filters in parallel. Filter backwash pumped to tailings).
KEY LAKE MINING CORP. SASK.	$400m^3/hr$	4) Lime/barium treatment of mine/mill effluents. (Lime neutralization of mill process streams in 4 stage agitated reactor with air addition, followed by clarifier settling. Barium chloride and lime are added to the clarifier decant in a 3 stage reactor. The treated stream is sent to a second clarifier. Solids from both clarifiers sent to tailings ponds).

TABLE 3 (cont'd)

SUMMARY OF URANIUM INDUSTRY WASTEWATER TREATMENT

MINE	EFFLUENT FLOW m^3/hr	TREATMENT PLANT DESCRIPTION
AMOK LTD. CLUFF LAKE, SASK.	$245m^3/hr$	5) Treatment of mill tailings decant. (Barium chloride aluminum sulphate, and soda ash added to four reactors in series. Solid/liquid separation in 3 sand filters run in parallel. Filter backwash pumped to tailings).
ELDOR MINES RABBIT LAKE, SASK.	N/A	6) Treatment of mill tailings decant. (Flow N/A, barium chloride, flocculants added for radium precipitation. Solid/liquid separation in sand filters).

2.2.1 Treatment Plant Distribution

A total of 42 effluent treatment facilities were identified. Of these, 28 are operated for base metal, 8 for precious metal, and 6 for uranium group effluents. Of the base metal group facilities, the majority (21) are operated at mine sites to treat acidic mine waters and tailings decants. Canadian smelters operate two effluent treatment systems, while refineries operate three. A system is in operation at an abandoned tailings site (Waite Amulet, Noranda, Quebec), and a plant at Copper Cliff handles the combined effluents of Inco's mine, smelter, and refinery effluents. All of the precious metal and uranium group facilities are operated at mine sites.

2.2.2 Effluent Treatment Processes

All base metal mines surveyed use alkali reagents for the neutralization of acidity and the precipitation of heavy metals. In nearly all cases, lime (either quicklime or slaked) is added, although Falconbridge uses finely ground limestone at one of its mines, and caustic soda at another. Treatment other than neutralization is uncommon for base metal effluents, with Westmin's Myra Falls alkaline chlorination facility the only one identified.

Precious metal mines deal mainly with effluents containing cyanides, and a variety of processes are indicated, including alkaline chlorination, SO_2-air, and H_2O_2 oxidation. Arsenic and antimony, when present, are precipitated using iron salts.

Uranium industry effluents are similar to base metal effluents, with lime treatment the predominant reagent used. Barium chloride is added in all cases to precipitate radium.

Polymers are always used as settling aids where mechanical solid/liquid separation is practiced. Their use is less common at plants with settling ponds.

Chemical reagents are generally added in agitated reactors, with the treated water then overflowing for solid-liquid separation mainly in either mechanical clarifiers (eg., lamella, reactor-type, or conventional), or settling ponds. Mechanical solid/liquid separation installations (including sand filters) are in use at 49% of the facilities, with 51% using natural settling (ie., sludge ponds, settling ponds, lakes, open pit mines, etc.). Facilities using clarifiers often recycle sludge to achieve increased sludge density (ie., High Sludge Density mode). Based on available survey information, the breakdown of settling options is shown in table 4:

TABLE 4 - SOLID/LIQUID SEPARATION PRACTICES

TYPE	NO. REPORTED	% OF TOTAL
Lamella Clarifier	3	7%
Reactor Clarifier	8	19%
Conventional Clarifier	7	16%
Settling (Sludge) Ponds	13	30%
Sand Filters	3	7%
Other (Tailings Ponds, Lakes, Open Pit Mines, etc.)	9	21%

2.2.3 SLUDGE DISPOSAL

Treatment plant sludges are ultimately disposed in a variety of methods, as indicated in Table 5:

TABLE 5 - SLUDGE DISPOSAL PRACTICES

METHOD OF DISPOSAL	NO. REPORTED	% OF TOTAL
Tailing Ponds	14	35%
Settling (Sludge) Ponds	17	43%
Recycled to Smelter	4	10%
Landfill	2	5%
Lake	2	5%
Open Pit Mine	1	2%

Settling ponds are in use at most locations providing both solid/liquid separation and sludge disposal. When the ponds become full, the sludge may be pumped to tailings, or the ponds abandoned, and new ones constructed. Sludge disposal directly to tailings ponds, (eg., by pumping of clarifier underflow) is practiced frequently, especially at locations where treatment plants are located close to tailings areas. At four locations, treatment plants operating in or close to smelters have found it advantageous to recycle these sludges for metals recovery.

In urban areas many of the above alternatives are unavailable, and disposal to an approved landfill is often the only option, as practiced by two study participants. Because of ever increasing costs for this type of disposal (eg., approximately $200/t in Quebec in 1986), alternate methods (eg., disposal to a smelter), may prove attractive in the long term.

Other disposal options indicated include lakes (three locations), and an abandoned open pit mine (one location).

2.3 SLUDGE CHARACTERISTICS

Plants operating effluent treatment facilities generally do not investigate sludge properties, and consequently, little information was received regarding the characteristics of sludges generated. The data obtained is summarized in Table 5, showing sludge solid content to vary betweer 1% and 40%. Plants which practice conventional solid/liquid separation (either in mechanical clarifiers or settling ponds), generally achieve sludge solids of 1% to 5%. At locations where sludge recycle occurs (ie., High Sludge Density mode), sludge solids of 10% to 40% are attained.

2.4 SLUDGE QUANTITIES

The annual volume of sludge generated by the Canadian Mineral industry treatment facilities was determined (based on the results of survey informations)to total 140,000 dry tonnes/year. Of this amount, 85% is produced by the base metal, 3% by the precious metal and 15% by the uranium mining industries.

TABLE 6 - SURVEY OF SLUDGE DATA - SOLIDS PERCENTAGE

Plant	Percent Solids	Comment
BM-1	5%	No clarifier, disposal to tail
BM-1	1%	Settling Ponds
BM-1	1%	No clarifier, disposal to tail
BM-2	3%	Conventional clarifier, no recycle
BM-6	2%	Reactor clarifier, no recycle.
PM-2	15-20%	Reactor clarifier, sludge recycle.
BM-7	1%	Clarifier, no sludge recycle
BM-5	2%	Reactor clarifier, sludge recycle.
BM-4	10-15%	Reactor clarifier, sludge recycle.
BM-3	7-10%	Sludge recycle operation.
BM-8	5%	No clarifier.
BM-9	20-30%	High sludge density operation.
PM-1	2-5%	Settling Ponds.
PM-3	2-5%	Reactor clarifier, no sludge recycle.
BM-11	5-10%	Sludge lagoon
BM-10	5-8%	Sludge pond

BM - Base metal industry facility
PM - Precious metal industry facility

3.0 SLUDGE CHARACTERIZATION STUDIES

A total of sixteen samples were received from representative companies of the Canadian Mineral Industry. Thirteen of the samples originated from base metal producers (twelve from mines or tailings areas, one from a smelter), while three came from precious metal mines. Most of the samples were of fresh sludge; however, samples received from BM-9 and BM-10 facilities were both of fresh sludge, and aged sludge from sludge storage ponds.

Due to regulatory restrictions on the shipment of radioactive wastes, (see Appendix 3), no samples from uranium producers were received.

The samples were all delivered by express transport to GML's laboratory in Dorval, Quebec in sealed plastic containers. Analysis of the samples was carried out for pH, total and suspended solids, density and sulphate levels. The samples were then digested to complete dissolution, and analysed by induced coupled plasma (ICP) emission spectroscopy for a wider range of elements.

3.1 ANALYTICAL RESULTS

The major elements (greater than 0.5% by weight on a dry sludge basis) as indicated by ICP analysis, are presented in Table 7 for each of the sludges analyzed. Based on the results, calcium, iron, and zinc (at an average percent of 11.4%, 6.5% and 6.1% respectively) were found to be the three main elements present in most of the sludges. Copper, lead, and nickel were less common and were found at greater than 0.5% in only two of the sludges each. Aluminum, magnesium, manganese and boron were present at similar levels in nine, fourteen, six and six sludges each respectively. Other less common elements were arsenic, cadmium, sodium and antimony. (The complete results of the ICP analyses are summarized in Table 9)

TABLE 7 - ICP SLUDGE ANALYSIS CONCENTRATIONS GREATER THAN 0.5% wt/wt dry sludge (wt %)

		Al	As	B	Ca	Cd	Cu	Fe	Mg	Mn	Na	Ni	Pb	Sb	Zn
BASE METAL															
BM-1		1.9	-	6.5	1.8	-	-	3.7	2.5	2.1	-	-	-	-	6.3
BM-2		0.63	1.2	2.2	1.1	2.4	-	1.2	5.6	0.7	1.8	-	2.0	-	7.0
BM-3		-	-	1.1	0.8	-	-	-	-	-	-	-	-	-	27.4
BM-4		-	-	-	34.4	-	-	0.6	1.2	-	-	-	-	-	5.2
BM-5		-	-	0.63	16.0	-	-	0.7	3.1	-	3.3	-	-	-	1.4
BM-6		-	-	-	8.2	-	-	29.4	2.1	-	-	-	-	-	2.6
BM-7		-	-	6.6	16.5	-	-	10.1	4.5	0.5	-	6.3	-	-	-
BM-8		-	-	-	14.7	-	-	6.6	4.4	-	-	-	-	-	1.6
BM-9	Fresh	1.0	-	-	2.5	-	-	25.3	7.3	1.5	-	-	-	-	2.4
BM-9	Aged	1.9	-	-	8.1	-	2.5	25.0	3.1	1.8	-	-	0.66	-	2.5
BM-10	Fresh	3.0	-	-	3.9	-	-	19.3	5.1	0.5	-	-	-	-	1.4
BM-10	Aged	2.0	-	-	5.8	-	-	20.5	4.2	-	-	-	-	-	0.9
BM-11		1.2	-	-	8.2	-	-	7.0	1.0	-	-	-	-	-	14.3
PRECIOUS METAL															
PM-1		2.4	-	2.1	20.8	-	-	2.7	1.6	-	-	-	-	-	-
PM-2		7.3	-	-	26.5	-	6.5	38.4	1.2	-	-	1.7	-	5.4	-
PM-3		-	1.5	-	13.6	-	-	16.9	-	-	6.5	-	-	-	-

TABLE 8 – SLUDGE ANALYSIS

		total solids %	suspended solids %	pH	density g/mL	sulfate wt %
BASE METAL						
BM-1		2.08	1.37	9.56	1.005	0.86
BM-2		3.63	3.22	10.30	1.010	0.05
BM-3		7.64	7.60	8.46	1.048	2.84
BM-4		20.55	-	9.38	1.135	0.45
BM-5		3.93	2.88	9.35	1.013	0.11
BM-6		1.87	1.22	8.22	1.003	0.43
BM-7		0.59	0.55	8.80	1.003	0.12
BM-8		0.35	0.16	9.84	1.000	0.12
BM-9	Fresh	20.60	-	9.43	1.132	1.87
BM-9	Aged	79.00	-	8.59	2.200	9.72
BM-10	Fresh	15.40	-	9.42	1.060	1.17
BM-10	Aged	25.90	-	9.16	1.170	2.83
BM-11		48.7	-	10.97	1.220	3.60
PRECIOUS METAL						
PM-1		2.81	2.23	10.68	1.008	1.00
PM-2		2.31	2.02	9.40	1.003	0.15
PM-3		2.01	0.76	7.47	1.004	0.15

TABLE 9 – ICP SLUDGE ANALYSIS
(metal content calculated on total solids)
(wt %/wt dry solids)

	Ag	Al	As	Au	B	Ba	Ca	Cd	Co
ASE METAL									
M-1	0	1.9	0	0	6.5	–	1.8	0.004	0.01
M-2	0.001	0.63	1.2	0	2.2	–	1.1	2.4	0.008
M-3	0	–	0	0	1.1	–	0.8	0.05	0.003
M-4	0	–	–	–	–	0.007	34.4	0.01	0.01
M-5	0	–	0	0	0.63	–	16.0	0.009	0.014
M-6	0	–	0	0	0	–	8.2	0.003	0.001
M-7	0	–	0	0	6.6	–	16.5	0	0.11
M-8	0	–	0	0	0	–	14.7	0	0.01
M-9 Fresh	0	1.0	0	0	0	< 0.001	2.5	0.01	0.005
M-9 Aged	0	1.9	0	0	0	0.003	8.1	0.005	0.006
M-10 Fresh	0	3.0	0	0	0	0.001	3.9	0.003	0.02
M-10 Aged	0	2.0	0	0	0	0.001	5.8	0.002	0.01
M-11	0	1.2	0	0	0	0	8.2	0.06	0.004
ECIOUS METAL									
M-1	0	2.4	0	0	2.1	–	21.0	< 0.003	0.013
M-2	0	7.3	0	0	–	0.19	26.5	< 0.001	< 0.001
M-3	0	0.12	1.5	0	< 0.001	0.006	13.6	< 0.001	0.009

	Cr	Cu	Fe	Hg	Mn	Mo	Na	Ni	Pb
SE METAL									
M-1	0	0.03	3.7	2.5	2.1	0	0	0.003	0
M-2	0	0.04	1.2	5.6	0.7	0	1.8	0.008	2.0
M-3	0	0.3	0.16	0.47	0.06	0	0	0.001	0.04
M-4	< 0.001	0.15	0.6	1.2	0.18	0	–	0.002	0.002
M-5	0	0.05	0.7	3.1	0.3	0	3.3	0.01	0.02
M-6	0	0.021	29.4	2.1	0.36	0	0.47	0.003	0
M-7	0	0.25	10.1	4.5	0.51	0	–	6.3	0
M-8	0	0.11	6.5	4.4	0.2	0	0.42	0.01	0
M-9 Fresh	0	0.4	25.3	7.3	1.5	0	0.01	0.01	0.02
M-9 Aged	0	2.5	25.0	3.1	1.8	0	0	0.01	0.07
M-10 Fresh	0	0.27	19.0	5.1	0.5	0	0	0.005	0.005
M-10 Aged	0	0.17	20.5	4.2	0.37	0	0	0.003	0.003
M-11	0	0.2	7.0	0.9	0.14	0	0	0.004	0.01
ECIOUS METAL									
M-1	0	0.48	62.7	1.6	0.37	0	–	0.03	0
M-2	0.01	6.5	38.4	1.2	0.17	0.08	–	1.7	0
M-3	0	0.27	16.9	0.34	0	0	6.5	0.002	0.004

Not Determined
Below Detection Limit

TABLE 9 cont'd - ICP SLUDGE ANALYSIS
(metal content calculated on total solids)
(wt %/wt dry solids)

	Sb	Si	Sn	Sr	Ti	U	V	W	Zn	CN
BASE METAL										
BM-1	0	-	-	0.01	0.01	0	0.001		6.3	-
BM-2	0	2.0	0	0.01	0.01	0	0.002	0	7.0	-
BM-3	0	-	0	0.004	0.004	0	0.001	0	27.4	-
BM-4	0	-	0	0.09	0.01	0	0.001	0	5.2	-
BM-5	0	-	0	0.15	0	0	0.001	0	1.4	-
BM-6	0	0.09	0	0.02	0.003	0	0.001	0	2.6	-
BM-7	0	-	0	0.03	0.09	0	0.005	0	0.09	-
BM-8	0	-	0	0.02	0	0	0	0	1.6	-
BM-9 Fresh	-	-	0	0.007	<0.001	0	0	0	2.4	-
BM-9 Aged	0	-	0	0.008	0.08	0	0	0	2.5	-
BM-10 Fresh	0	-	0	0.007	0.05	0	0	0	1.4	-
BM-10 Aged	0	-	0	0.01	0.08	0	0	0	0.9	-
BM-11	0	-	0	0.02	0.05	0	0	0	14.3	-
PRECIOUS METAL										
PM	0	-	0	0.07	0.004	0	0.001	0	0.26	0
PM-2	5.4	-	0	0.02	0.09	0	0.03	0	0.19	0.11
PM-3	0	-	0	0.25	0	0	0.001	0	0.11	0.005

(-) Not Determined
(0) Below Detection Limit

The results of pH, sulphate and physical sludge analysis parameters (density, total solids, suspended solids) are presented in Table 8. As shown, sludge total solids varied from 0.5% to 79%; those below 5% originated mainly from settling ponds and conventionally operated clarifier, while those greater than 15% were taken from clarifiers operated in the High Sludge Density Mode.

Suspended solids values are similar, but lower than total solids. Density levels were mostly in the 1 to 1.2 range, and appeared to correlate to total solids levels. The pH ranged from 7.47 to 10.97, with a majority of values falling between pH 8.5 to 9.5. Sulphate values varied from approx. 1% to 3.6%.

3.2 DISCUSSION OF RESULTS

3.2.1 Base Metal vs Precious Metal Sludges

A comparison of precious metal sludge analyses (PM) to the base metal values indicates similar results, with the only significant difference to be the low zinc content of the former. Additionally, the PM-3 sludge had the highest arsenic content of all samples received (1.46%) while PM-2 was the only one with antimony (5.43%).

3.2.2 Mine vs Smelter Sludges

The sample from BM-2 was the only one representative of smelter effluent treatment sludges. A comparison of BM-2 analysis to the remaining samples indicated the main variation to be high cadmium and lead levels. The remaining parameters evaluated were similar to the rest of the samples.

3.2.3 Fresh vs Aged Sludges

A comparison of fresh and aged sludge samples from the same locations indicates similar characteristics, with most of the parameters with in 100% of each other. The variation in values is probably attributable to normal fluctuations in effluent quality.

The total solids content of both aged samples was significantly higher than that of the fresh samples. This difference is due to on-going consolidation and dewatering of these sludges which occurs in the sludge storage facilities at these mines.

4.0 SLUDGE LEACHING STUDIES

4.1 METHODOLOGY

Field evaluations of environmental effects associated with the disposal of solid wastes are complex and very costly. Thus, methodologies to assess the possible extent of contaminant release in a field disposal situation have traditionally been in the form of bench-scale leaching tests. A number of leaching test protocols have been proposed, [2, 3] however to date there is no uniformity over the test conditions, and no general agreement over the adoption of a standard protocol. The parameters to consider in a leaching test include:

4.1.1 Column Tests vs Batch Tests

In column tests, the leaching medium is passed through solid waste material in a column. Batch tests, on the other hand, consist of agitating a waste sample in a liquid solution over a specific time. While column tests provide a closer representation of field conditions, the duration can range from weeks to months.

Also, due to such factors as channeling, non-uniform packing of waste and clogging, the results may not be reproducible from test to test.

Batch tests are faster, and easier to perform, with a time duration generally of 24 hrs. Since test conditions can be controlled easier over the short test duration, the results tend to be more reproducible. Thus, most protocols utilize batch tests.

4.1.2 Leaching Medium

The characteristics (i.e. composition, pH,) of the leaching medium will determine to a large extent the release of contaminants from a solid wastes. Typical leaching medium used in laboratory studies are:

- Distilled water
- Buffered acidic solutions
- Synthetic municipal landfill leachate

Table 10 present the chemical composition of leaching media proposed by Environment Canada. (4)

TABLE 10 - CHEMICAL COMPOSITION OF TYPICAL LEACHING MEDIA

Leaching Medium	Chemicals Added To Distilled Water	Concentration M
Distilled water	---	---
Acidic solution	Acetic acid	0.082
	Sodium acetate	0.045
Synthetic municipal landfill leachate	Acetic acid	0.15
	Sodium acetate	0.15
	Glycine	0.05
	Salicylic acid	0.007

4.1.3 Liquid to Solid Ratio

The liquid to solid ratio for use in batch studies (i.e. leaching medium to solid waste) generally is determined by practical considerations, including a volume that will yield sufficient volume for analysis, and analytical instrument detection limits for contaminant determination. Generally, liquid to solid ratios vary between 4 and 20 to 1. (2, 3, 4)

4.1.4 Test Duration

Batch leaching tests have been shown to reach equilibrium in relatively short time duration, and a 24 hr period is generally used.

4.1.5 Study Leaching Procedures

Following a review of existing protocols,[2 to 4] and contact with Environment Canada,[5] a procedure for the leaching of mineral industry sludges was developped, as follows:

1. 500 mL square polyethylene sample bottles were used
2. A tumbler-type agitator was rotated at 30 RPM to provide efficient contact between the leaching medium and waste samples
3. A liquid to sludge weight ratio of 1:10 was selected
4. The time duration for each test was 24 hrs
5. Six leaching tests were conducted on each sludge sample, using leaching media as follows:

   - Distilled water adjusted to pH 4 with H_2SO_4
   - Distilled water adjusted to pH 2.5 with H_2SO_4
   - Distilled water, H_2SO_4 added as needed to maintain pH at 4 during 24 hr. leaching period
   - Distilled water, H_2SO_4 added is needed to maintain pH at 2.5 during 24 hr. leaching period
   - Distilled water, with acetic acid (0.082 M) and sodium acetate (0.045 M)
   - Distilled water

6. At the end of the tests, the liquid was decanted, and filtered through a glass fibre filter. Samples for most metal analysis were preserved with nitric acid. Samples for CN determination were preserved with NaOH. All metals were determined using atomic absorption with direct aspiration. CN determinations were performed by the Tartaric Acid Method [6]

4.2 LEACHING TEST RESULTS

The results of the leaching studies of mineral industry wastewater treatment sludges are presented in table 11 and indicate the following:

- The release of contaminants from the sludges is highly related to the final pH of the leachates.

- When distilled water is used as the leaching medium, final pH values were generally alkaline and above pH 8, indicating substantial residual alkalinity in the sludges.

- The use of acetic acid/sodium acetate solution does not appear to result in higher leach results than sulphuric acid. Final leach pH values are indicated as the predominant factor of contaminant levels.

- Contaminant release in leach liquor was also related to initial concentration of metals in the sludge. Thus, lead, cadmium, nickel, and arsenic were present in low concentrations in most sludge samples, as well as leach solutions. Where these elements are present at levels above 0.5% (e.g. BM-2, PM-2 and BM-7), low leach pH solutions contained significantly higher contaminant concentrations.

- The highest release and leach solutions concentrations were for zinc, iron, and copper, with levels as high as 5200 mg/L Zn, 770 mg/L Fe, and 93 mg/L Cu.

- Both old and fresh sludges appeared to result in similar leach contaminant concentrations, (i.e. BM-9, BM-10).

TABLE 11 - LEACHATE ANALYSIS

	LEACHING PROCEDURE	* Initial pH	Final pH	Pb (mg/L)	Cu (mg/L)	Ni (mg/L)	Zn (mg/L)	Fe (mg/L)	Sb (mg/L)	As (mg/L)	CN (mg/L)	Cd (mg/L)	Cr (mg/L)
BASE METALS													
BM-1	L1	4.00	8.96	0	0	0	0	0	-	-	-	0	-
	L2	2.50	6.70	0	0	0	16.0	0.3	-	-	-	0.1	-
	L3	4.00	4.00	0	0.3	0.2	95.0	0.5	-	-	-	0.1	-
	L4	2.30	2.30	0	0.4	0.3	120.0	45.0	-	-	-	0.1	-
	L5		4.66	0	0.3	0	90.0	2.0	-	-	-	0.1	-
	L6		9.83	0	0	0	0	0	-	-	-	0	-
BM-2	L1	4.00	9.86	0	0.3	0	0	0	-	0.006	-	0	-
	L2	2.50	8.90	0	0.3	0	0	0	-	-	-	0.2	-
	L3	3.90	3.90	6.7	0.3	0.5	220.0	1.0	-	-	-	63.0	-
	L4	2.67	2.67	4.2	0.4	0.6	225.0	4.1	-	2.7	-	63.0	-
	L5		5.47	12.0	0.2	0.5	208.0	0.3	-	0.57	-	59.0	-
	L6		10.39	0	0	0	0	0	-	-	-	0.1	-
BM-3	L1	4.00	8.30	0	0		1.3	0	-	-	-	0.1	-
	L2	2.50	6.96	0	0	0	7.5	0	-	-	-	0.7	-
	L3	4.05	4.05	1.5	21.0	0.3	1900.0	1.0	-	-	-	3.2	-
	L4	2.56	2.56	2.0	21.0	0.3	1900.0	6.4	-	-	-	3.2	-
	L5		5.52	2.0	18.0	0.4	1900.0	0.3	-	-	-	2.7	-
	L6		8.77	0	0	0.2	2.7	0	-	-	-	<0.1	-
BM-4	L1	4.00	9.39	0	0	0	0	0				0	0
	L2	2.50	8.72	0	0.1	0	0	0				0	0
	L3	4.10	4.10	0	12.0	0.8	970.0	5.5	-	-	-	2.1	0
	L4	2.59	2.59	0.5	13.0	1.0	970.0	22.0	-	-	-	2.2	0
	L5	4.50	6.25	0	2.0	0.7	680.0	0	-	-	-	0.4	0
	L6		9.85	0	0	0	1.5	0	-	-	-	0	0
									-	-	-	-	-
BM-5	L1	4.00	9.32	0	0	0	0	0	-	-	-	0	-
	L2	2.50	8.87	0	0	0	0	0	-	-	-	0	
	L3	4.00	4.21	0	2.0	0.8	310.0	3.0	-	-	-	0.4	-
	L4	2.50	2.58	0.5	3.0	0.9	375.0	25.0	-	-	-	0.4	-
	L5	4.50	5.30	0	1.0	0.7	400.0	1.0	-	-	-	0.4	-
	L6		8.47	0	0	0	0.8	0	-	-	-	0	-
BM-6	L1	4.00	8.20	0	0	0	0	0	-	-	-	0	-
	L2	2.50	5.42	0	0.7	0	13.0	2.0	-	-	-	0.1	-
	L3	4.00	4.13	-	0.3	0	34.0	2.5	-	-	-	0.1	-
	L4	2.50	2.40	0	0.3	0.3	30.0	87.0	-	-	-	0.1	-
	L5	4.50	4.60	0	0.3	0.2	21.0	1.0	-	-	-	0.1	-
	L6		7.88	0	0	0	0	0	-	-	-	0	-
BM-7	L1	4.00	8.66	0	0	1.2	0	0.5	-	-	-	0	-
	L2	2.50	6.78	0	0	9.5	0	0.5	-	-	-	0	-
	L3	4.00	4.24	0	0.8	28.3	0.6	0.3	-	-	-	0	-
	L4	2.50	2.40	0	1.1	33.0	0.6	42.0	-	-	-	0	-
	L5	4.50	4.64	0	1.0	27.5	1.1	1.0	-	-	-	0	-
	L6		8.91	0	0	1.0	0	0.5	-	-	-	0	-
BM-8	L1	4.00	8.98	0	0.3	0	0.9	0	-	-	-	0	-
	L2	2.50	3.16	0	0.7	0	5.9	6.1	-	-	-	0	-
	L3	4.00	4.03	0	0.3	0	5.7	3.1	-	-	-	0	-
	L4	2.50	2.67	0.1	0.5	0.3	6.1	22.0	-	-	-	0	-
	L5	4.50	4.61	0.2	0.5	0.2	6.5	2.0	-	-	-	0	-
	L6		9.05	0	0	0	0.1	0	-	-	-	0	-
BM-9	L1	4.00	9.10	0	0	0	0.1	0	-	-	-	-	0
	L2	2.50	8.87	0	0	0	0.1	0	-	-	-	-	0
	L3	4.00	4.34	1.0	11.0	2.3	365.0	0	-	-	-	1.5	-
	L4	2.50	2.72	5.0	66.0	2.5	420.0	125.0	-	-	-	1.8	-
	L5	4.50	7.87	1.0	0	0	0.1	0	-	-	-	0	-
	L6		9.23	0	0	0	0.1	0	-	-	-	0	-
BM-9-O	L1	4.00	8.27	0	0	0	0.1	0	-	-	-	0	-
	L2	2.50	8.17	0.3	0	0	0.1	0	-	-	-	0	-
	L3	4.00	4.27	1.0	0.8	4.5	850.0	0.5	-	-	-	1.2	-
	L4	2.50	3.29	4.0	7.5	5.5	1265.0	6.0	-	-	-	2.3	-
	L5	4.50	7.40	0.7	9	9	0.2	0	-	-	-	0	-
	L6		9.17	0	0	0	0.1	0	-	-	-	0	-
BM-10	L1	4.00	9.28	0	0	0	0	0.5	-	-	-	0	-
	L2	2.50	9.10	0	0	0	0.1	0.5	-	-	-	0	-
	L3	4.00	4.10	0.3	18.6	1.0	232.0	1.0	-	-	-	0.4	-
	L4	2.50	2.54	0.8	49.0	1.3	266.0	770.0	-	-	-	0.5	-
	L5	4.50	7.17	0.4	0	0.2	1.4	0.5	-	-	-	0	-
	L6		9.17	0	0	0	0	0	-	-	-	0	-

* Leaching Procedure - see note end of Table

TABLE 11 cont'd – LEACHATE ANALYSIS

		Initial pH	Final pH	Pb (mg/L)	Cu (mg/L)	Ni (mg/L)	Zn (mg/L)	Fe (mg/)	Sb (mg/L)	As (mg/L)	CN (mg/L)	Cd (mg/L)	Cr (mg/L)
BH-10-0	L1	4.00	9.14	0	0	0	0	0.5	-	-	-	0	-
	L2	2.50	8.88	0	0	0	0.1	0.5	-	-	-	0	-
	L3	4.00	4.22	0	6.6	0.7	170.0	2.0	-	-	-	0.3	-
	L4	2.50	2.73	0.4	58.0	0.8	330.0	220.0	-	-	-	0.7	-
	L5	4.50	7.90	0.4	0	0.2	0.1	0	-	-	-	0	-
	L6		9.03	0	0	0	0	0	-	-	-	0	-
BH-11	L1	4.00	11.07	0	0	0	0.3	0	-	-	-	0	-
	L2	2.50	11.07	0	0	0	0.2	0	-	-	-	0	-
	L3	4.00	4.15	0	55.0	1.3	5120.0	1.0	-	-	-	18.0	-
	L4	2.50	2.56	1.9	93.0	1.5	5380.0	690.0	-	-	-	21.0	-
	L5	4.50	10.49	0.4	0	0.3	0.1	0.5	-	-	-	0	-
	L6		11.16	0	0	0	0	0	-	-	-	0	-
PRECIOUS METALS													
PM-1	L1	4.00	10.67	0	0.2	0	0.1	1.5	-	-	-	0	-
	L2	2.50	10.06	0	0.2	0	0	0.5	-	-	-	Tr	-
	L3	4.00	4.21	0	11.0	1.3	7.6	0	-	-	0.02	0.1	-
	L4	2.50	2.62	0	13.0	1.5	8.1	67.0	-	-	-	0.1	-
	L5	4.50	4.72	0	11.0	1.0	7.5	14.0	-	-	0.02	0.1	-
	L6		9.30	0	0	0	0	0	-	-	-	0	-
PM-2	L1	4.00	9.40	0	1.7	0.5	0.1	8.6	1.1	-	-		-
	L2	2.50	7.98	0	0.4	0.3	0	1.5	-	-	-	0	0
	L3	4.00	4.13	0	40.0	18.3	2.0	0.3	-	-	0.8	0	-
	L4	2.50	2.56	0	55.0	21.1	2.4	94.0	0.014	-	-	-	-
	L5	4.50	4.72	0	39.0	13.6	2.3	0.5	0.11	-	0.1	0	0
	L6		7.32	0	0.2	0	0	1.0	-	-	-	0	0
PM-3	L1	4.00	7.30	0	0	0	0	0	-	0.012	-	0	-
	L2	2.50	3.40	0	4.4	0	1.6	1.0	-	-	-	0	-
	L3	4.0	4.02	0	3.4	0	1.5	0	-	-	0.06	0	-
	L4	2.50	2.57	0	4.7	0	1.6	55.0	-	0.118	-	0	-
	L5	4.50	4.57	0.3	3.2	0.2	1.4	0	-	0.014	0.05	0	-
	L6		7.50	0	0	0	0	0	-	-	-	0	-

* LEACHING PROCEDURE

L1: 1/10 dilution of sludge in H_2SO_4 solution at initial pH 4

L2: 1/10 dilution of sludge in H_2SO_4 solution at initial pH 2.5

L3: 1/10 dilution of sludge in H_2SO_4 solution maintained pH 4

L4: 1/10 dilution of sludge in H_2SO_4 solution maintained at pH 2.5.

L5: 1/10 dilution of sludge in acetic acid & sodium acetate solution at imitial pH 4.5.

L6: 1/10 dilution of sludge in distilled water.

OTHERS NOTATION

(-) Not determined
(0) Below detection limit

4.3 DISCUSSION

In Canada, solid waste disposal is regulated at the provincial level. Most provinces have enacted Hazardous Waste Regulations using leaching test as a criterion. The Quebec Hazardous Waste Regulations [7] define a hazardous waste as one whose leachate concentrations exceed the quantities indicated in Table 12. A comparison of these values with the leaching test results indicate Zn, Ni, Cd, Cu to be elements exceeding the Quebec regulatory requirements in up to 50% of the sludges samples tested (Table 13).

The Quebec Hazardous Waste Regulations require solid wastes classified as hazardous to be disposed to an approved site. The situation is similar in the other provinces. The results of this study suggest that effluent treatment sludges produced by the Canadian Mineral Industry effluent treatment facilities are hazardous in many cases, and that the current disposal methods are inadequate from the regulatory point of view. As indicated, in many cases these sludges are currently disposed with mine tailings.

The long term effects of such disposal is not well defined, and further research is needed to elucidate such disposal.

TABLE 12 - QUEBEC HAZARDOUS WASTE LEACHING CONCENTRATIONS

Elements	Waste Hazardous if following concentration (mg/L) exceeded
Total Arsenic	5.0
Total Cadmium	2.0
Total Chromium	5.0
Total Copper	10.0
Total Nickel	10.0
Total Lead	5.0
Total Zinc	10.0

TABLE 13 - SAMPLES EXCEEDING QUEBEC REGULATIONS

Elements	% of samples exceeding Quebec Regulations (*)
As	0%
Cd	13%
Cr	0%
Cu	19%
Ni	13%
Pb	6%
Zn	50%

(*) Based on Quebec Leaching Protocol (7)

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1. Energy, Mines and Resources Canada, Canadian Minerals Yearbook 1984-1985: Review and Outlook.

2. ASTM, "Proposed Methods for Leaching of Waste Materials", 1979 Annual Book of ASTM Standards, Part 31 (Water), 1979.

3. U.S. EGM, "Test Methods for Evaluating Solid Wastes", Office of Water and Waste Management, Report SW-846, August, 1980.

4. Cote, P.L., Constable, T.W. "Development of a Canadian Data Base on Waste Leachability", Hazardous and Industrial Solid Waste Testing: Second Symposium, ASTM STP. 805. American Society for Testing and Materials, 1983.

5. Cote, P.L., Letter to S. Crevier, December 23, 1985.

6. Cyanide Analysis in Mine Effluents, technical seminar presented by K. Conn, Environmental Protection Service, Environment Canada, Jan. 22/81.

7. Hazardous Waste Regulation, Gazette Officielle du Quebec, June 26, 1965, Vol. 117, No. 28.

APPENDIX 1

MINE TREATMENT PLANT

SURVEY DATA

PROJECT DATA SHEET

COMPANY NAME AND LOCATION:

.....

.....

MILLING OR PRODUCTION RATE:

.....

SOURCES OF WASTE WATER:

.....

FLOW RATE:

.....

WATER PARAMETER
Before treatment:

pH .....

Acidity .....

SO_4 .....

Zn .....

Fe .....

Cu .....

Pb .....

As .....

Cd .....

Others .....

TREATMENT DESCRIPTION:

.....

.....

.....

.....

.....

.....

.....

REAGENT ADDITION:

Line .....

Polymers .....

SLUDGE PRODUCTION:

Per cent solids .....

Sludge quantities .....

SLUDGE DISPOSAL:

.....

.....

.....

.....

.....

.....

Please return to:

M. Wasserlauf
Les Associés Gionet, Mellor, Liebich Ltee
175 Blvd. Bouchard
Dorval, Québec
H9S 1A9

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1985 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tpd)	%	%	%	%	(g/tonne)		(tonnes)	(tonnes)				(kilograms)		
Schumacher	2,720	0.04	—	—	—	3.22	3.29	758,363	157	—	—	—	1,557	2,113	
Royex Gold Mining Corp Goldlund Sioux Lookout	180	—	—	—	—	—	4.46	56,152	—	—	—	—	—	215	
Barrick Resources Corp Renabie Mine	450	—	—	—	—	1.78	4.94	110,487	—	—	—	—	194	507	
Sulpetro Minerals Limited Canadaka Division	270	—	—	—	—	105.26	—	47,633	—	—	—	—	3,378	—	
Teck Corporation Pan Empire Cobalt	180	—	—	—	—	0.17	3.43	47,554	—	—	—	—	3	82	
Westfield Minerals Limited Scadding Twp.	180	—	—	—	—	—	6.82	20,562	—	—	—	—	—	110	
Manitoba															
Hudson Bay M&S Co Ltd Flin Flon/Snow Lake	10,500	2.47	—	0.12	2.85	18.80	1.51	1,905,813	43,375	—	42,143	1,464	26,676	1,838	
Inco Limited Thompson	12,700	0.14	1.88	—	—	5.14	0.10	2,518,900	2,969	42,000	—	—	10,105	158	Stockpiled ore from the Pipe open pit, was processed in 1985.
Sherritt Gordon Mines Ltd Fox mine Lynn Lake	2,725	1.62	—	—	2.20	14.06	0.58	663,164	9,782	—	12,552	—	5,325	207	Mine closed November 28, 1985 due to exhaustion of reserves
Ruttan mine Leaf Rapids	9,070	1.47	—	—	0.91	10.63	0.34	1,413,317	19,589	—	10,807	—	8,582	296	Production commenced from deepening project.
British Columbia															
Branda Mines Ltd. Peachland	27,220	0.15	—	—	—	1.47	0.03	6,109,067	7,826	—	—	—	4,486	79	Mine reopened September 15, 1985.
Broken Hill Prop Co Ltd Island Copper mine	37,200	0.43	—	—	—	1.61	0.21	16,360,918	59,443	—	—	—	13,143	1,781	In-pit crusher and conveyor completed. Mine also recovers molybdenum and rhenium.
Carolin Mines Ltd. Hope	1,360	—	—	—	—	0.31	3.36	236,581	—	—	—	—	19	488	
Cominco Ltd. Valley Copper Mine	18,145	0.50	—	—	—	3.43	0.03	8,452,682	37,850	—	—	—	14,442	121	
Sullivan Mine Kimberley	9,070	—	—	5.10	4.02	58.29	—	2,472,236	—	—	93,080	116,576	126,606	—	
Dickenson Mines Limited Silmonac mine New Denver	110	—	—	10.40	6.17	733.71	—	7,382	—	—	427	765	5,275	—	
Equity Silver Mines Ltd	5,300	0.59	—	—	—	122.80	1.17	2,089,710	9,021	—	—	—	143,837	748	
Erickson Gold Mining Ltd Cassiar	180	—	—	—	—	7.89	10.63	83,153	—	—	—	—	476	780	
Esso Resources Ltd Granduc Mine	7,260	1.58	—	—	—	12.69	0.20	278,278	4,206	—	—	—	2,909	42	
Gibraltar Mines Limited McLeese Lake	36,290	0.31	—	—	—	0.82	—	13,142,194	33,920	—	—	—	5,476	—	Decision made to install 5,000 tpy copper leaching, solvent extraction, electrowinning operation in 1986.
Lornex Mining Corp Ltd Highland Valley	72,575	0.35	—	—	—	1.78	0.00	28,162,932	86,369	—	—	—	25,087	—	
Mosquito Creek GM Co Ltd The Caribou	90	—	—	—	—	7.20	23.88	2,113	—	—	—	—	13	42	
Newmont Mines Limited Similkameen, Princeton	19,960	0.39	—	—	—	1.92	0.17	6,518,308	21,677	—	—	—	6,250	525	
Noranda Inc. Babine Lake	1,360	3.36	—	—	2.19	19.20	—	138,799	4,131	—	1,259	—	1,339	—	Mine did not operate in 1985.
Scottie Gold Mines Ltd. Summit Lake	180	—	—	—	—	7.20	16.18	43,685	—	—	—	—	307	623	
Teck Corporation Afton Operating Corp	6,805	0.68	—	—	—	4.46	0.46	2,639,082	30,189	—	—	—	7,644	945	
Highmont Operating Corp Highland Valley	22,680	0.22	—	—	—	—	—	6,049,857	11,775	—	—	—	—	—	Mine remained closed through 1985.
Beaverdell mine Beaverdell	110	—	—	0.20	0.40	322.63	—	36,795	—	—	109	61	10,394	—	
Westmin Resources Limited Buttle Lake	907 (2700)	1.02	—	1.03	7.42	105.60	2.26	203,636	1,947	—	14,057	1,979	19,014	405	H.W. orebody brought into production
Yukon Territory															
United Keno Hill Mines Ltd Elsa	450	—	—	2.38	0.32	675.43	—	65,888	—	—	112	1,045	38,713	—	
Northwest Territories															
Cominco Ltd Con Yellowknife	590	—	—	—	—	3.77	13.71	221,479	—	—	—	—	783	2,772	
Polaris Mine Little Cornwallis Is	2,050	—	—	3.82	13.71	—	—	819,083	—	—	108,333	30,283	—	—	
Echo Bay Mines Ltd. Lupin mine Contwoyto Lake	1,090	—	—	—	—	1.71	12.03	493,078	—	—	—	—	832	5648	
Giant Yellowknife Mines Ltd Giant Mine	1,090	—	—	—	—	1.54	7.82	295,333	—	—	—	—	310	1,884	
Salmita	180	—	—	—	—	4.90	26.19	55,069	—	—	—	—	257	1,381	
Nanisivik Mines Ltd. Nanisivik	1,500	—	—	1.14	10.20	47.73	—	892,900	—	—	67,558	7,473	27,653	—	
Pine Point Mines Limited Pine Point mine	10,000	—	—	2.30	7.60	—	—	2,278,873	—	—	163,485	51,089	—	—	
Royex Gold Mining Corp Cullaton Lake	300	—	—	—	—	0.82	7.89	128,629	—	—	—	—	50	908	
Terra Mines Ltd. Smallwood and Norex Camsell River	360	—	—	0.15	0.10	1229.49	—	20,274	—	—	12	—	24,378	—	

Principal Canadian nonferrous and precious metal mine production in 1984

Company and Mine/Mill Location	Capacity	Grades of Ore Milled						Ore Milled	Metal Contained in All Concentrates Produced						1985 Highlights
		Cu	Ni	Pb	Zn	Ag	Au		Copper	Nickel	Zinc	Lead	Silver	Gold	
	(tpd)	%	%	%	%	(g/tonne)		(tonnes)	(tonnes)				(kilograms)		
Newfoundland															
ASARCO Incorporated Buchans	1,089	2.11	–	6.95	10.79	115.2	0.75	92,533	1,560	–	8,325	4,718	78,788	518	Mine closed.
Newfoundland Zinc Mines Ltd Daniel's Harbour	1,497	–	–	–	8.20	–	–	498,952	–	–	40,349	–	–	–	
New Brunswick															
Brunswick M and S Corp Ltd Bathurst	10,500	0.32	–	3.54	8.87	99.09	–	3,560,208	8,748	–	271,094	98,430	2,036	–	
Heath Steele Mines Ltd Newcastle	3,830	–	–	–	–	198.34	4.83	130,866	–	–	–	–	14,550	463.4	
Quebec															
Agnico-Eagle Mines Ltd Joutel	1,090	–	–	–	–	0.96	6.17	332,720	–	–	–	–	288	1,882	
Aiguebelle Resources Inc.	1,000	–	–	–	–	1.23	3.49	226,824	–	–	–	–	247	753	
Bachelor Lake G M Inc Desmaraisville	450	–	–	–	–	0.48	4.80	141,599	–	–	–	–	65	625	
Barrick Resources Corp. Camflo	1,130	–	–	–	–	0.38	4.15	431,687	–	–	–	–	96	1,690	
Belmoral Mines Ltd. Val d'Or	1,360	–	–	–	–	0.86	8.23	200,159	–	–	–	–	164	1,556	
BP Resources Canada Ltd. Selco; Joutel	1,500	3.15	–	–	0.89	31.3	1.27	551,259	16,638	–	3,578	–	15 349	609	Company started development work to bring its A1-Zone into production in 1986. Exploration work on A2-Zone began in late 1985.
Campbell Resources Inc., Chibougamau	3,175	1.08	–	–	–	7.20	2.95	334,788	3,486	–	–	–	1,446	837	
Corp Falconbridge Copper															
Lake Dufault Division Noranda	1,542	2.98	–	–	2.73	24.66	1.03	489,245	13,979	–	10,755	–	7,732	447	
Lake Shortt Division Chapais	750	–	–	–	–	0.29	3.81	80,300	–	–	–	–	9	208	
Opemiska Division Chapais	2,722	1.18	–	–	–	9.94	2.85	822,345	8,998	–	–	–	4,909	1,597	
Kiena Gold Mines Limited	1,250	–	–	–	–	1.10	5.73	91,856	–	–	–	–	78	449	
Lac Minerals Ltd. Doyon Division	1,090	–	–	–	–	0.58	5.70	519,884	–	–	–	–	289	2,839	
Est-Malartic Division	1,630	–	–	–	–	0.34	4.53	822,526	–	–	–	–	202	2,843	
Terrains Aurifères Dvn	1,800	–	–	–	–	1.82	6.84	525,060	–	–	–	–	790	3,349	
Muscocho Explorations Ltd Montauban Mine	230	–	–	–	–	5.83	4.77	123,294	–	–	–	–	649	531	
Noranda Inc.															
Gaspé Division Murdochville	3,719	1.48	–	–	–	7.65	.09	355,481	5,106	–	–	–	2,039	7	Development of E-32 Zone continued.
Horne Division Chadbourne Circuit	3,447	–	–	–	–	2.23	3.74	26,685	–	–	–	–	587	863	
Les Mines Gallen	–	–	–	–	5.03	20.85	1.30	84,242	–	–	3,305	–	880	55	
Mattagami Division	3,950	1.21	–	–	5.04	20.37	0.45	1,067,356	11,421	–	48,451	–	11,181	194	Exploration outlining possible orebody.
Northgate Patino Mines Inc Copper Rand	2,939	1.59	–	–	–	9.81	4.11	671,889	10,398	–	–	–	4,102	2,409	
Sigma Mines (Quebec) Ltd Val d'Or	1,270	–	–	–	–	0.75	4.25	433,824	–	–	–	–	326	1 772	
Société Minière Louvem Inc. (Soquem)	544	–	–	–	–	1.37	3.74	75,298	–	–	–	–	103	282	The Chimo mine was closed to August 1985.
Teck Corporation Lamaque Division	1,900	–	–	–	–	0.86	4.87	570,810	–	–	–	–	507	2,827	Lamaque Mine shut down during 1985.
Ontario															
Agnico-Eagle Mines Limited Cobalt	360	–	–	–	–	967.20	0.0	52,880	–	–	–	–	49,840	–	
Campbell Red Lake Mines Ltd Red Lake	975	–	–	–	–	2.06	19.85	358,365	–	–	–	–	665	6,654	
Detour Joint Venture James Bay	2,500	–	–	–	–	0.65	3.33	794,561	–	–	–	–	469	2 456	Open pit mine scheduled to close in Sept. 86.
Consolidated Louanna G M Ltd Hauna	181	–	–	–	–	2.57	7.03	53,303	–	–	–	–	109	352	
Dickenson-Sullivan Red Lake	910	–	–	–	–	1.37	11.68	187,672	–	–	–	–	218	1,890	
Dome Mines Limited South Porcupine	2,720	–	–	–	–	0.79	4.87	780,179	–	–	–	–	585	3,685	
Falconbridge Limited Sudbury district	10,340	1.18	1.29	–	–	6.86	0.14	2,882,000	31,545	30,940	–	–	1,278	1,989	
Gail Resources Inc. Timmins	450	–	–	–	–	6.86	7.99	68,039	–	–	–	–	449	508	Production intermittent.
Inco Limited Sudbury and Shebandowan	49,440	1.23	1.30	–	–	5.14	0.17	16,870,000	125,512	115,850	–	–	43,818	11,372	
Inco/Queenston J/V	450	–	–	–	–	0.21	2.81	114,882	–	–	–	–	22	286	
Kerr Addison Mines Ltd Virginiatown	1,225	–	–	–	–	0.17	3.98	348,836	–	–	–	–	55	1,349	
Kidd Creek Mines Ltd. Timmins	12,250	2.76	–	0.32	8.30	105.63	3.77	4,512,813	120,188	–	258,552	8,012	393,836	174	Gold from 81,585 t treated in gold circuit.
Lac Minerals Ltd. Macassa Kirkland Lake	454	–	–	–	–	2.06	18.17	152,949	–	–	–	–	302	2,689	
Mattabi Mines Limited Mattabi and Lyon Lake	2,700	0.96	–	0.91	8.33	130.97	0.45	843,855	7,353	–	65,837	6,420	98,308	264	
Noranda Inc. Geco Manitouwadge	3,850	1.79	–	0.14	3.13	50.08	0.14	1,253,855	21,563	–	38,644	1,185	48,390	89	
Pamour Porcupine Mines, Ltd Pamour Timmins	2,720	–	–	–	–	0.89	2.54	877,078	–	–	–	–	373	1,967	Sold to Jimberlana Resources during 1985.

APPENDIX 2

PERSONNEL CONTACTED

LIST OF INDUSTRY PERSONNEL CONTACTED

	COMPANY	INDIVIDUAL
NEW BRUNSWICK	Brunswick Mining and Smelting Corporation Mining Division Bathurst, N.B. Tel: (506) 506-6671	S. Sampson
	Brunswick Mining and Smelting Corporation Smelting Division Bathurst, N.B. Tel: (506) 548-8157	P. Evans
NOVA SCOTIA	Rio Algom Kemptville, N.S. Tel: (902) 761-2311	K. Black
QUEBEC	Falconbridge Copper Corp. Lac Dufault Div. Noranda, Quebec Tel: (819) 762-7783	P. Pelletier
	Kiena Gold Mines Ltd. Val d'Or, Quebec Tel: (819) 738-4031	R. Lemieux
	Lac Minerals Ltd. Doyon Division Bousquet-Rouyen, Quebec Tel: (705) 567-4911	G. Hope
	Muscocho Explorations Ltd. Montauban, Quebec Tel: (418) 336-2777	G. Lachance

QUEBEC	Teck Corporation Lamaque Division Val d'Or, Quebec Tel: (819) 824-6845	B. Van Tassel G. Proulx
	Noranda Inc. Horne Division Noranda, Quebec Tel: (819) 762-7764	P. Godbehere
	Noranda Inc. Chadbourne Division Noranda, Quebec Tel: (819) 764-9548	P. Godbehere
ONTARIO	Campbell Red Lake Mines Ltd. Balmertown, Ontario Tel: (807) 735-2075	B. Carlin
	Denison Mines Elliot Lake, Ontario Tel: (705) 848-9111	C. Chackravatti
	Dickenson-Sullivan Joint Venture Balmertown, Ontario Tel: (807) 735-2077	L. Connell
	Dome Mines Ltd. S. Porcupine, Ontario Tel: (705) 235-3221	R. Calhoun
	Falconbridge Ltd. Sudbury, Ontario Tel: (705) 693-2761	J. Weglo

ONTARIO	Detour Lake Mine Timmins, Ontario Tel: (705) 245-3212	P. Creston
	INCO Metal Co. Copper Cliff, Ontario Tel: (705) 682-8248	P. Bolger
	Kidd Creek Mines Ltd. Timmins, Ontario Tel: (705) 235-8121	M. Nakado
	Noranda Inc. Geco Division Manitouwadge, Ontario Tel: (807) 826-3211	W. Sencza
	Noranda Inc. Golden Giant Mine Tel: (807) 238-1121	R. Tessier
	Renabie Mines Missanabie, Ontario Tel: (705) 234-2333	C. Bodoin
	Teck-Corona Marathon, Ontario Tel: (807) 238-1041	C. Myers
	Rio Algom Elliot Lake, Ontario Tel: (705) 461-1800	A. Vizyurka
MANITOBA	Hudson Bay Mining and Smelting Co. Ltd. Flin Flon, Man. Tel: (204) 687-5221	W. Fraser

MANITOBA	Sherrit Gordon Mines Ltd. Lynn Lake, Man. Tel: (204) 356-2571	G. Vickell
	INCO Limited Thompson, Man. Tel: (204) 677-5211	J. Ashton
SASKATCHEWAN	Key Lake Mines Key Lake, Sask. Tel: (306) 884-2100	M. Neven
	Eldor Mines Sask. Tel: (306) 382-0505	R. Phillips
	Cluff Mines Amok Ltd. Saskatoon, Sask. Tel: (306) 242-8894	T. Meadley
ALBERTA	Sherritt Gordon Refinery Edmonton, Alberta Tel: (403) 998-6911	
BRITISH COLUMBIA	Cominco Ltd. Sullivan Mune Kimberley, B.C. Tel: (604) 427-2484	W. Kuit
	Equity Silver Mines Ltd. Houston, B.C. Tel: (604) 845-7799	R. Patterson
	Erickson Gold Mining Corp. Cassiar, B.C. Tel: (403) 668-5638	J. Yce

BRITISH COLOMBIA	Gibraltar Mines Ltd. McLeese Lake, B.C. Tel: (604) 297-6211	J. Taylor
	Lornex Mining Corp. Logan Lake, B.C. Tel: (604) 575-2443	K. Brown
	Westmin Resources Ltd. Campbell River, B.C. Tel: (604) 287-9271	R. Van Dyke
NORTHWEST TERRITORIES	Cominco Ltd. Yellowknife, N.W.T. Tel: (604) 364-4222	W. Kuit
	Echo Bay Mines Ltd. Lupin, N.W.T. (Environment Canada) Tel: (403) 873-3456	D. Sutherland
	Giant Yellowknife Mines Ltd. Yellowknife, N.W.T. (Environment Canada)	D. Sutherland
	Pine Point Mines Ltd. Pine Pont, N.W.T. (Environment Canada)	D. Sutherland

LIST OF GOVERNMENT AGENCIES CONTACTED

	Department	Individual
NOVA SCOTIA	Department of the Environment tel : 902-424-5300	Mr. J.Laydon
NEW BRUNSWICK	Department of the Environment Fredericton, N.B tel : 506-453-3753	Mr. Kresta
NEWFOUNDLAND	Department of the Environment St-John, Newfoundland tel : 709-576-2555	Mr. L.Hulett
QUEBEC	Ministere de l`Environnement Montreal,Quebec tel : 514-873-3636	Mr. R.Duquette
ONTARIO	Ministry of the Environment Toronto, Ontario tel : 416-965-6995	Mr. Hawley
MANITOBA	Department of the Environment Winnipeg, Manitoba tel : 204-945-6522	Mr. E.Duffield

SASKATCHEWAN	Department of the Environment Regina, Sakatchewan tel : 306-953-2224	Mr. Meekan
ALBERTA	Department of the Environment Edmonton, Alberta tel : 406-427-5888	Mr. W. Anhulak
BRITISH COLUMBIA	Ministry of the Environment Victoria, B.C tel : 604-387-5975 tel : 604-387-4321	Mr. T.Kalmans Mr. J.Weldon
FEDERAL	Environment Canada Ottawa, Ontario tel : 819-997-2270	Mr. J.Scott

APPENDIX 3

URANIUM SHIPMENT RESTRICTION INFORMATION

AMOK LTD
AMOK LTEE

817 - 825 45th STREET WEST, P.O. BOX 9204, SASKATOON, SASKATCHEWAN S7K 3X5

February 10, 1986

Gionet Mellor Liebich Associates
175 Boulevard Bouchard
Suite 120
Dorval, Quebec
H9S 1A9

Attention: Mark Wasserlauf

Dear Mr. Wasserlauf:

Re: GML Project No. 7227

In response to your letter of January 29, 1986, I am pleased to advise that we are prepared to forward to you the requested samples of sludges from our primary and secondary treatment facilities.

However, there are a number of conditions that we must impose in order to satisfy various regulatory requirements:

(1) We require a written authorization from the Atomic Energy Control Board that indicates that we may forward this material to you (activity is approximately 80 Bq/g Ra-226). This must be in a form that satisfies the following condition in our operating license:

12. ore, waste, mill tailings or any other contaminate material or equipment shall not be removed from the facility without the prior written approval of the Board;

and assures us that we are meeting the following additional condition:

20. transfers of prescribed substances within Canada shall only be made to persons authorized by the Regulations to possess such prescribed substances.

(2) We require that you agree to reimburse us for any costs that we may incur in preparing this material for shipment. In particular, you should be aware that we will need a shipping container for this material that meets the requirements of the Transport Packaging of Radioactive Materials

Regulations and the Transportation of Dangerous Goods Regulations. Since this material is wet, we propose to package it as though it were liquid.

(3) We require that you agree to accept responsibility for this material from the time that it leaves our property at Cluff Lake, and agree that you are the owner of this material during transportation.

Should you require any clarification of the above, please contact me.

Yours truly,

Tim Meadley,
Director RPHS & EP

TM:blz
Our Ref: M028-86